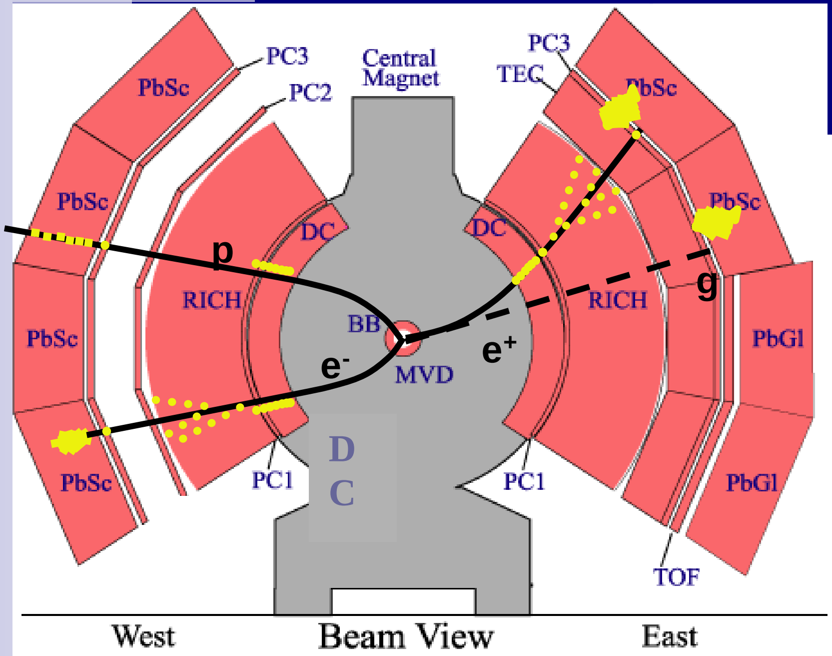
E.Kistenev, BNL, PHENIX

Direct photons in PHENIX at RHIC



2 central arms:

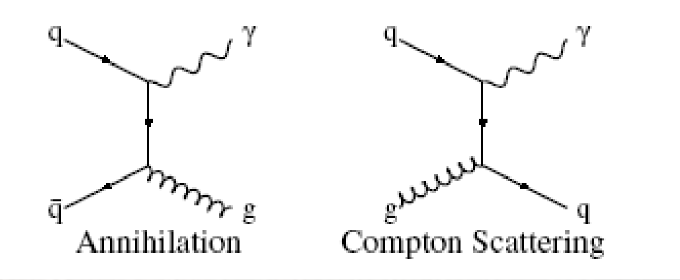
electrons, photons, hadrons

Talk outline:

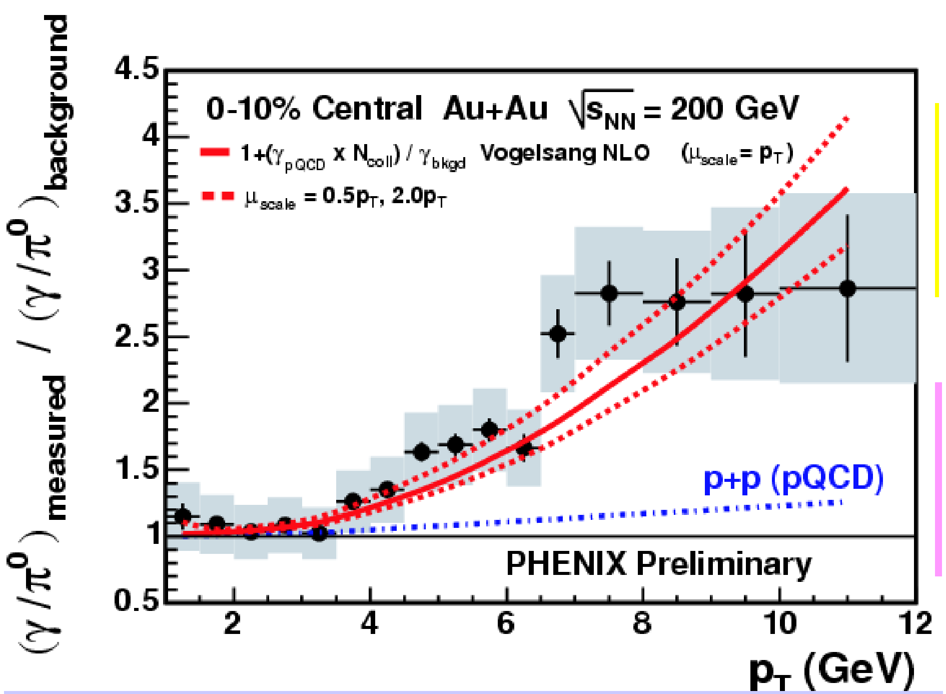
- **Direct γ yield**
- **FF measurements**
- **Flow**

Direct (prompt) photons

- **30% of energy released when two particles collide are photons;**
- **Most are tertiary, they are products of electromagnetic decays of secondary hadrons and leptons;**
- **Some are direct – produced in partonic hard scattering, emitted by fragmenting partons or by media during freese out;**
- **Those due to hard scattering are also called prompt, their production in NN interactions is well studied and commonly used as a proof of validity for pQCD treatment**



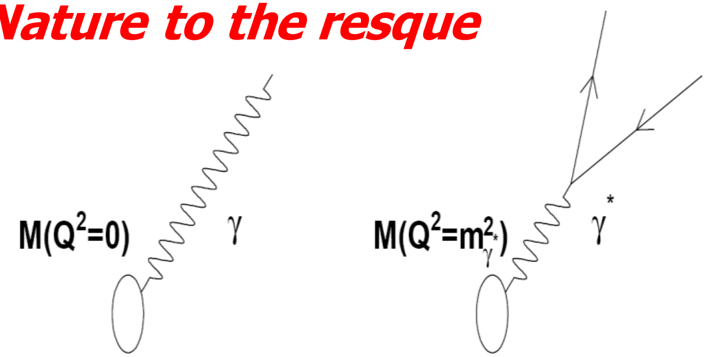
Direct photons – real and virtual



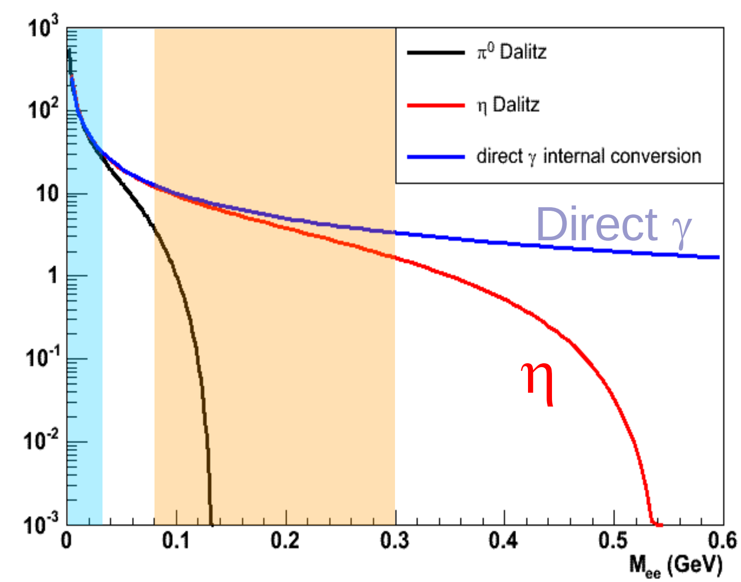
Huge γ/π^0 ratio at high pT reflects high-pT hadron (π^0) suppression in AuAu central collisions

Excess at low p_T is less then 15% so precision measurements of direct photon yield in thermalreagion are notoriously difficult

Nature to the resque



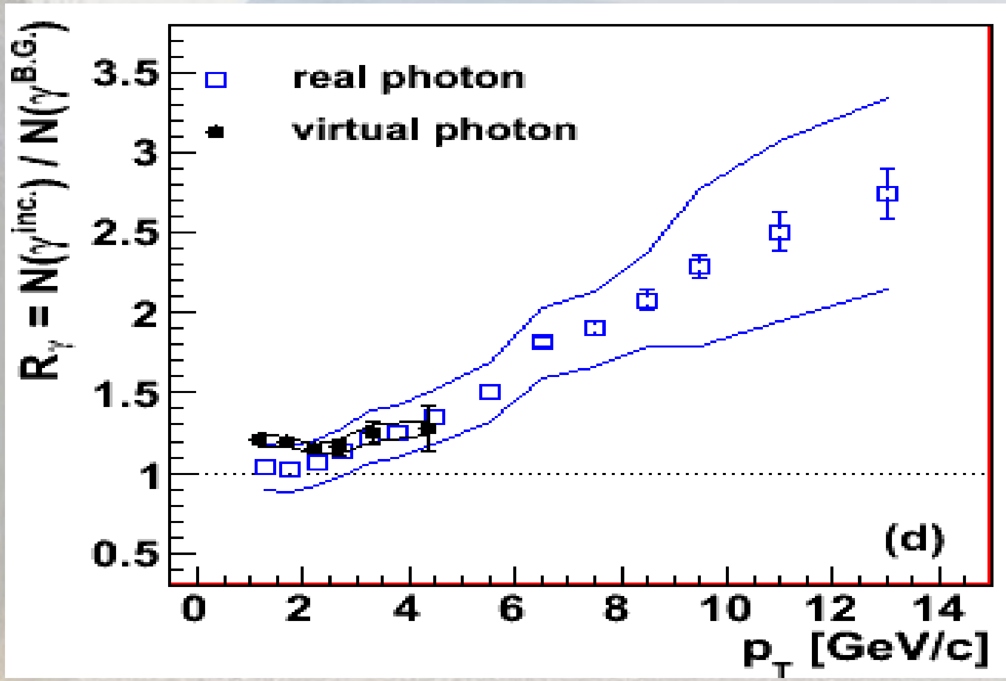
Real photon yield can be measured from virtual photon yield, which is observed as low mass e^+e^- pairs



Virtual photons (internally converted)

Relation between the γ^* yield and real photon yield is known (Kroll-Wada formular in case of hadrons (π^0, η), equality in case of direct photons)

$$\frac{d^2N}{dM_{ee}} = \frac{2\alpha}{3\pi}\sqrt{1-\frac{4m_e^2}{M_{ee}^2}}\left(1+\frac{2m_e^2}{M_{ee}^2}\right)\frac{1}{M_{ee}}S(M_{ee},p_t)dN_\gamma$$ where $$S(M_{ee},p_t)\equiv\frac{dN_{\gamma^*}}{dN_\gamma}$$



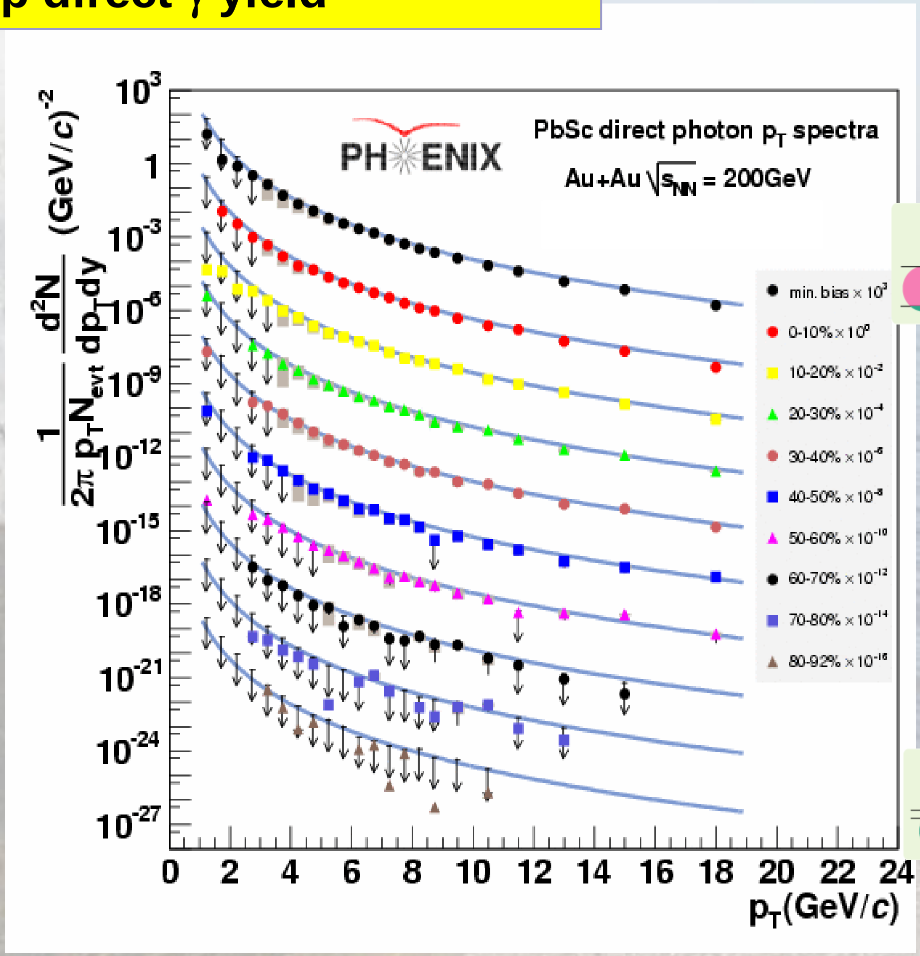
One parameter fit: $(1-r)f_c + r\,f_d$ here f_c: cocktail calc., f_d: direct photon calc.

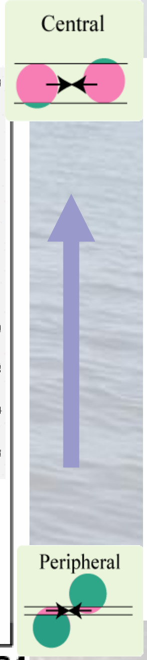
$$r = \frac{\gamma^*_{dir}(m>0.15)}{\gamma^*_{inc}(m>0.15)} \propto \frac{\gamma^*_{dir}(m\approx 0)}{\gamma^*_{inc}(m\approx 0)} = \frac{\gamma_{dir}}{\gamma_{inc}}$$

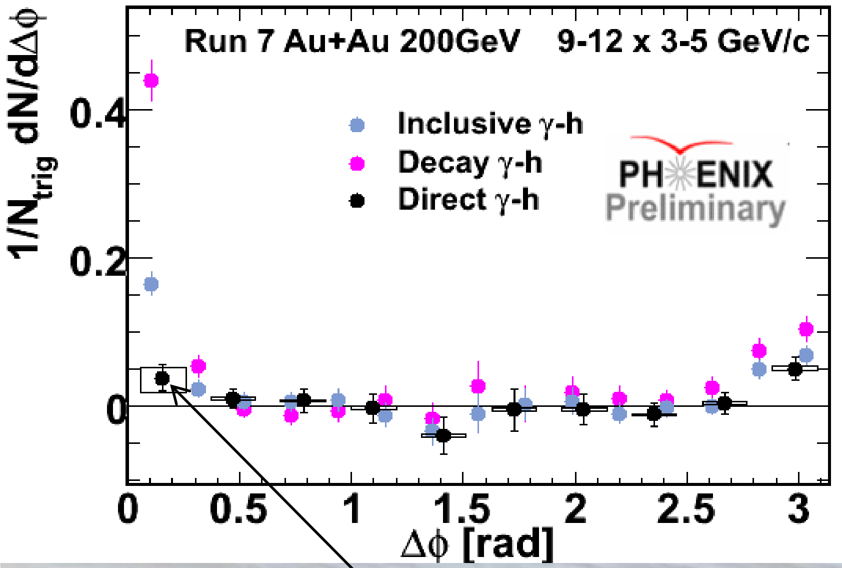
Direct photons in AuAu 200 GeV

Curves: collision scaled pp direct γ yield

Photons in calorimeters 2001-2010



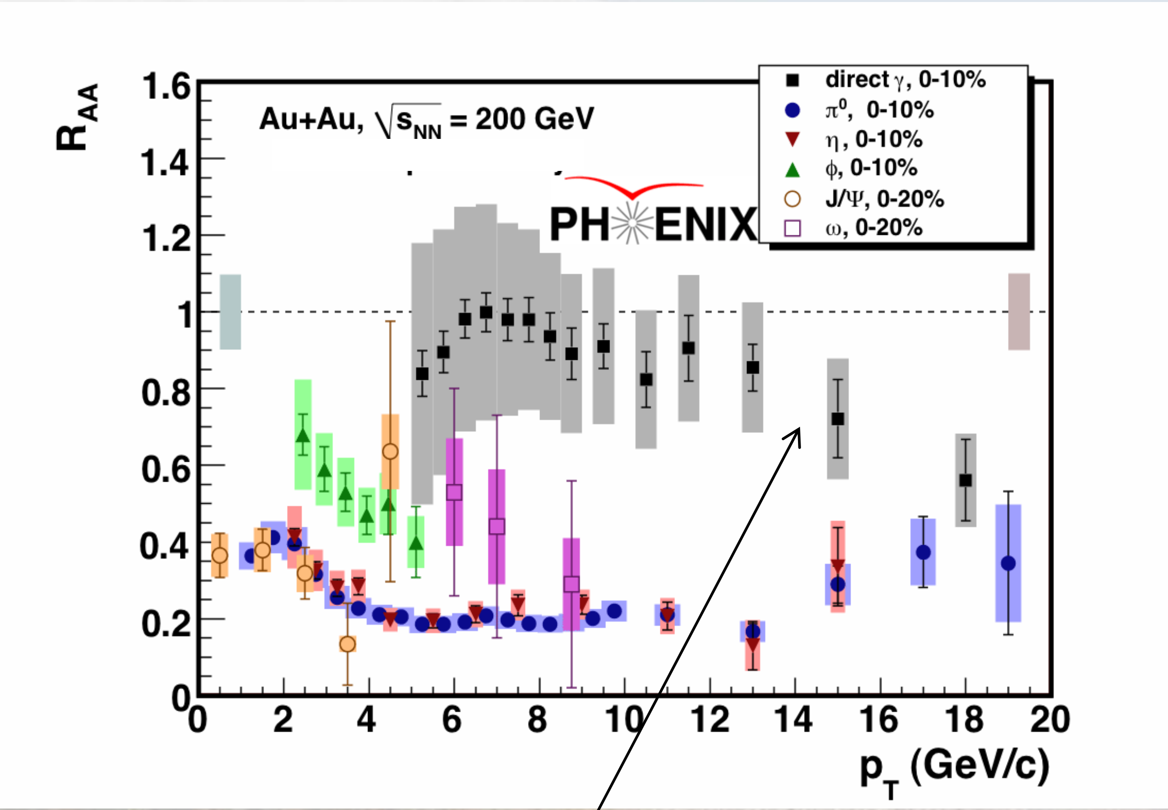


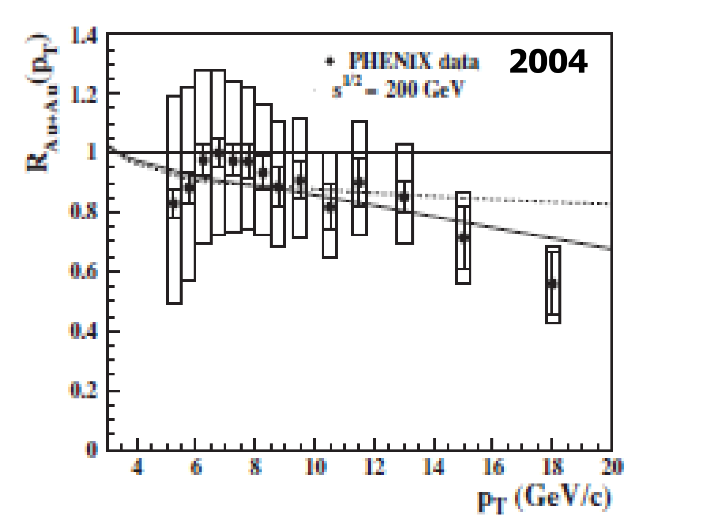


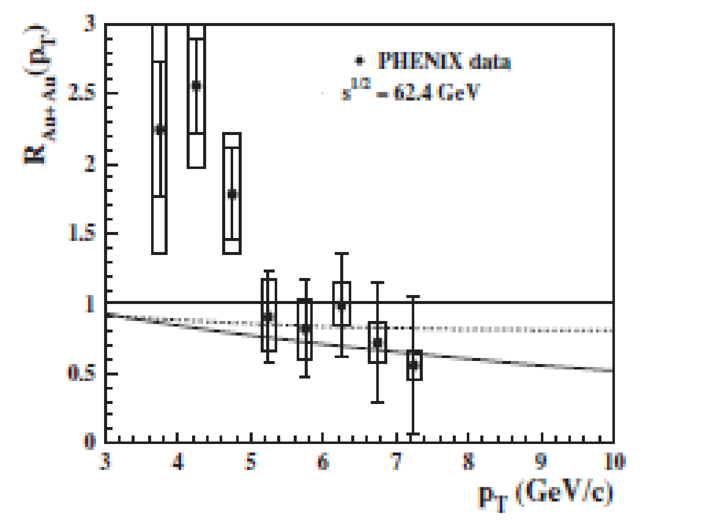
Hard prompt photons are isolated

collision scaling works in AuAu

pQCD photons RAA







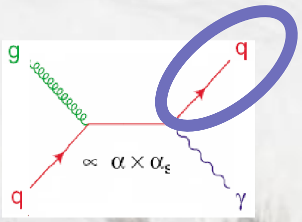
Isospin effect (Arleo: wave function differences between p and n**)?**

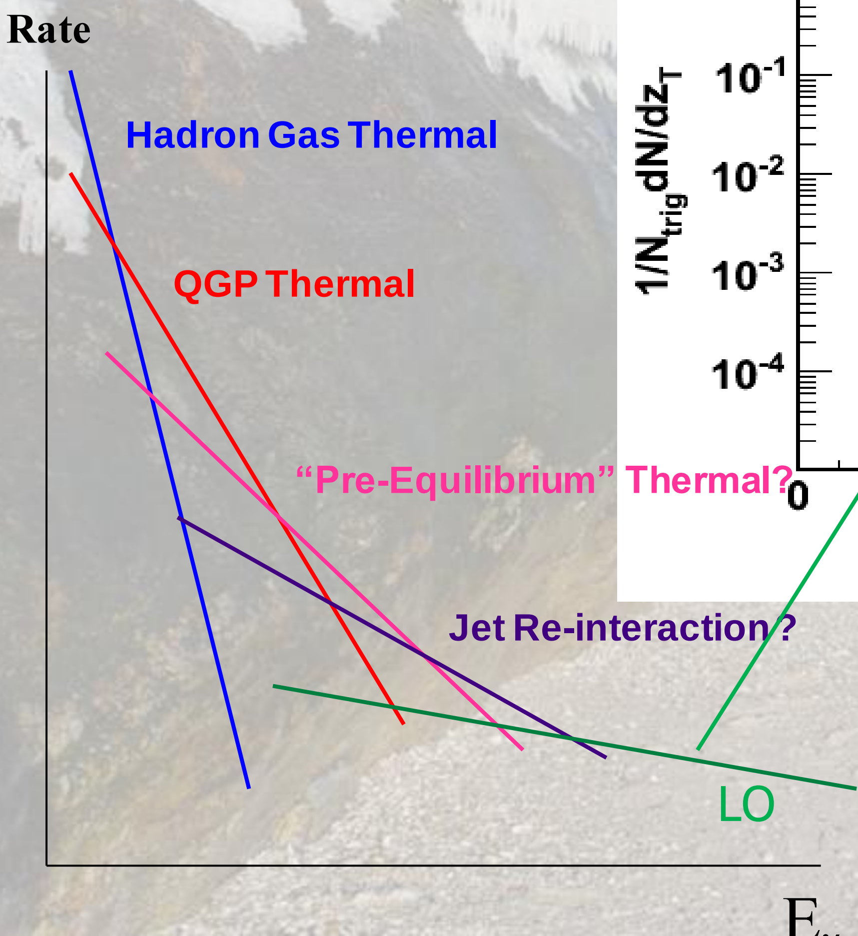
Initial state effect?

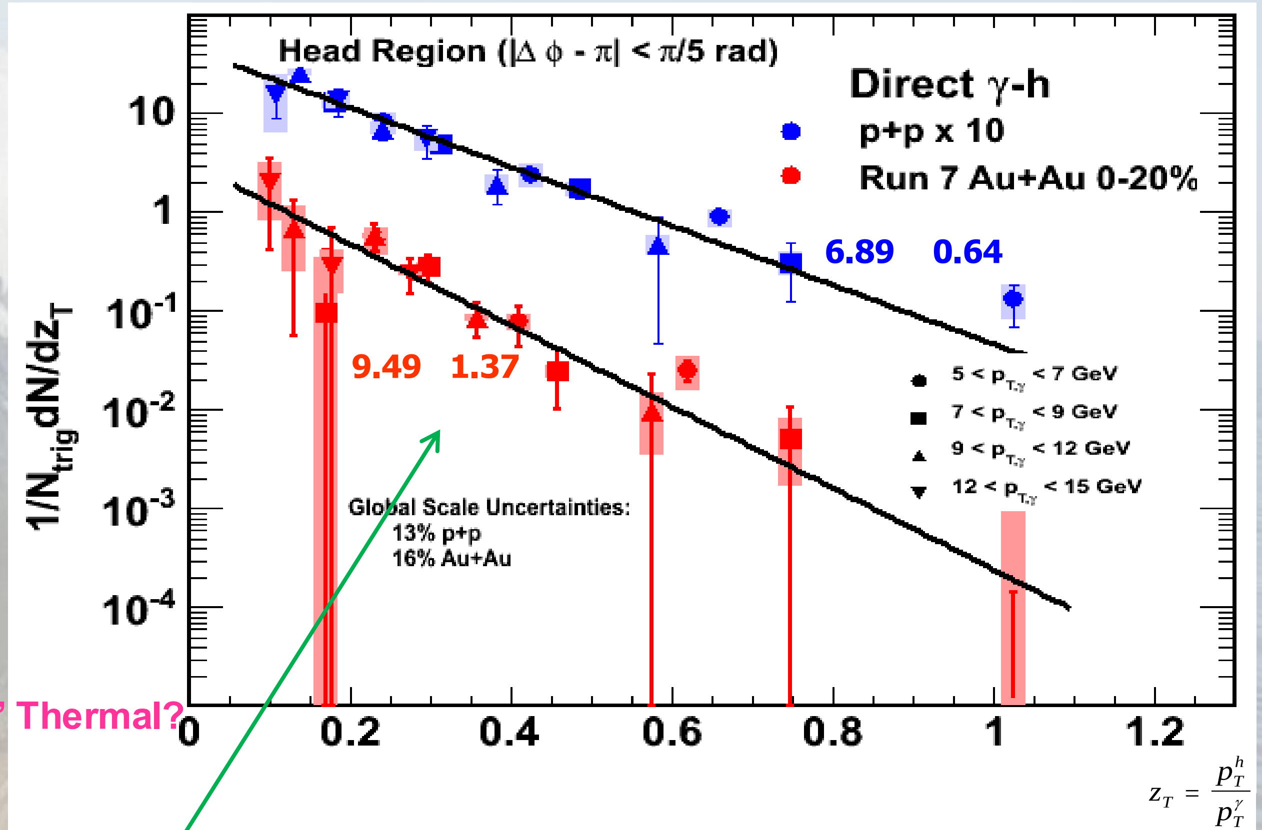
Initial state effect: "energy deficit" induced by multiple interactions in CNM. B.Kopeliovich, J.Nemchik,

J. Phys. G: Nucl. Part. Phys. 38 (2011) 043101 (43pp)

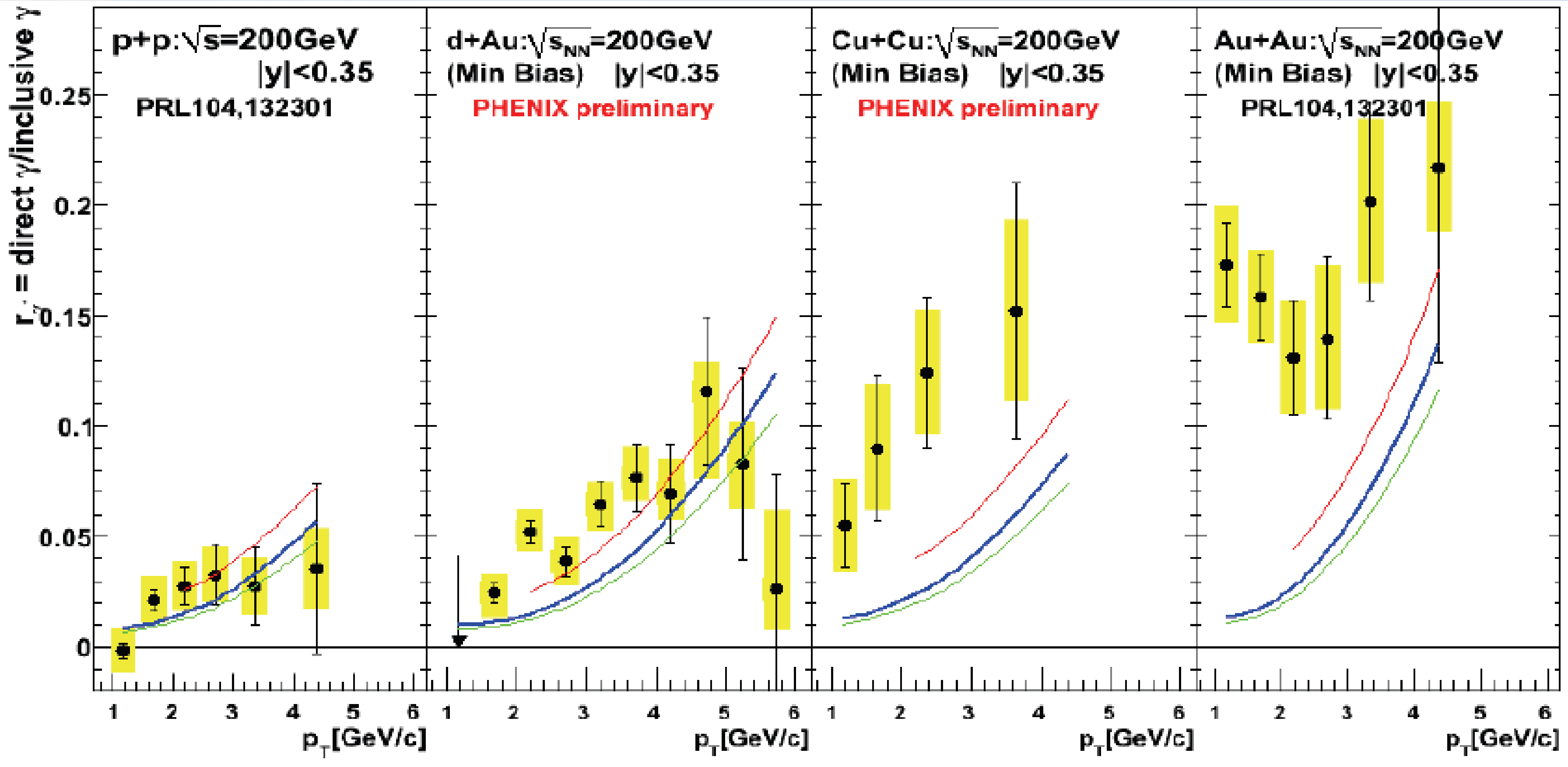
pQCD photons and partonic FF







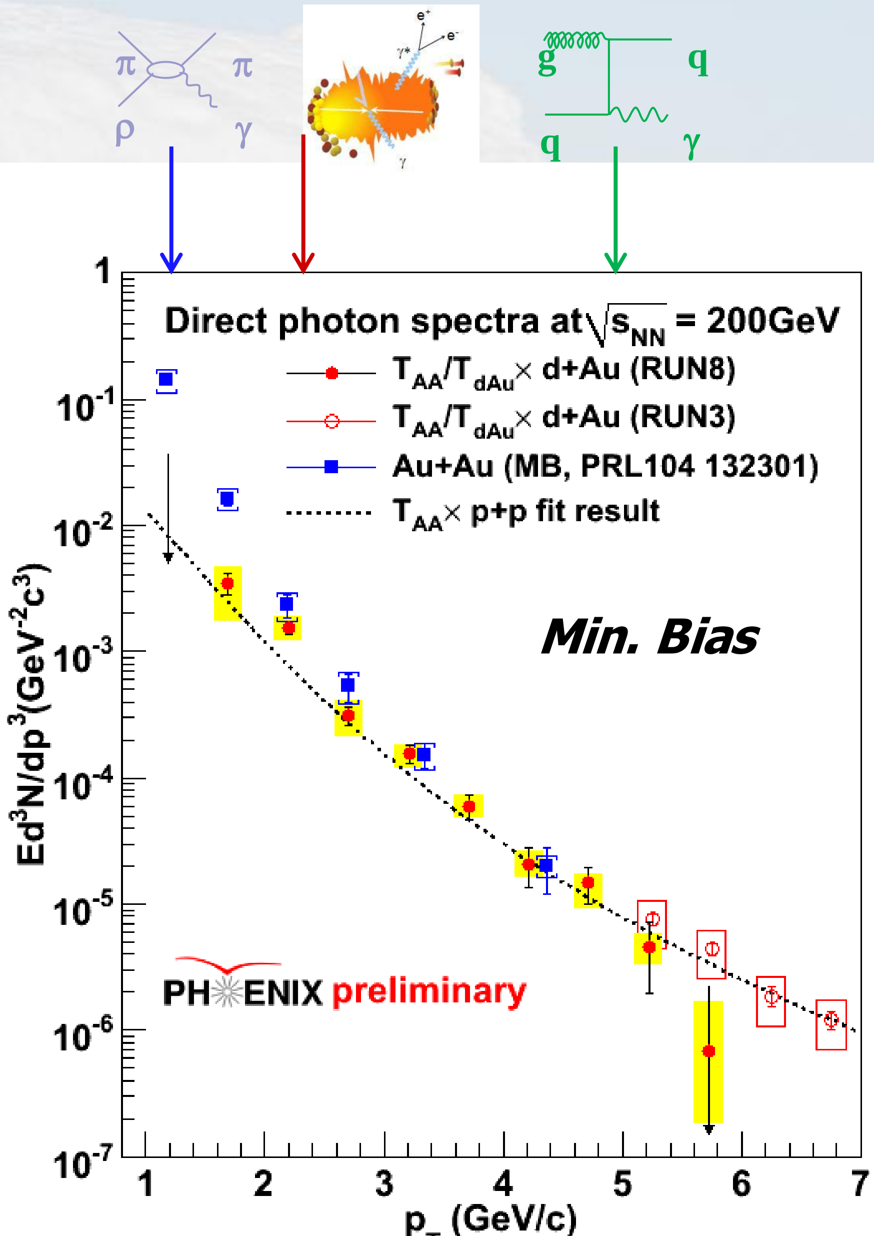
Emerging thermal γ's



Virtual photon measurement helped to extend pT range down to ~1 GeV/c and establish thermal dominance in the direct γ yield below pT~5 GeV/c

first reliable sighting of thermal enhancement

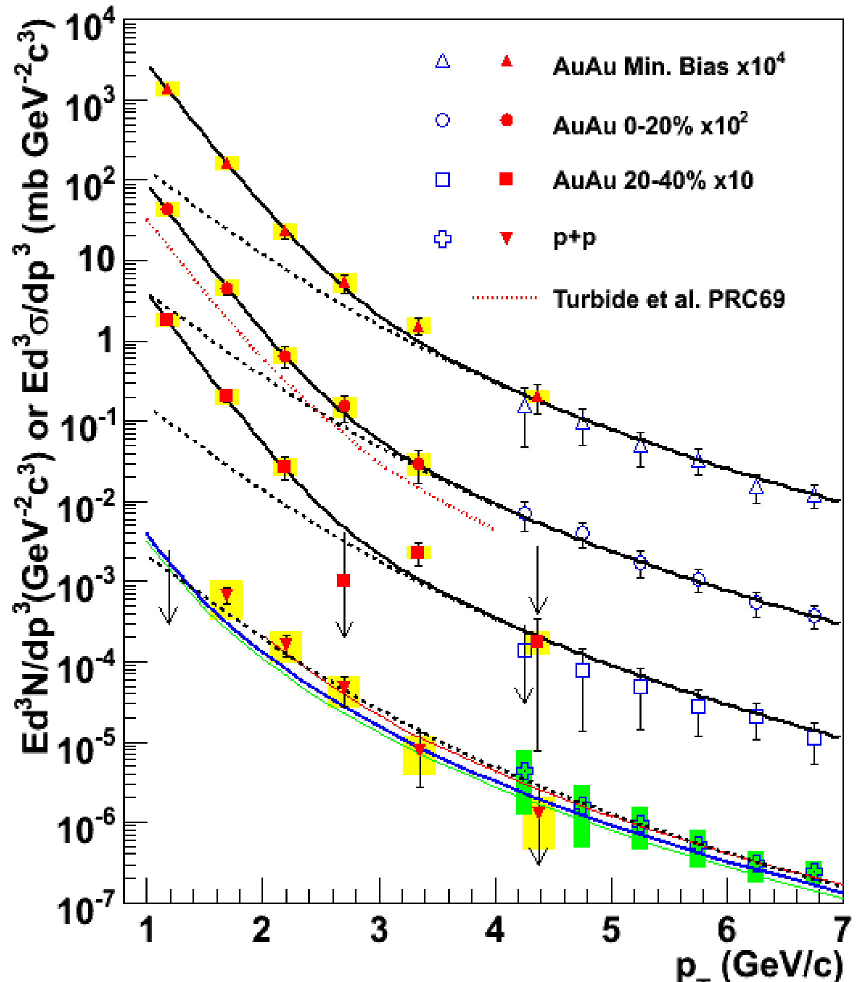
Thermal enhancement



Exp fit to Au+Au data / scaled pp data:

T_{ave} = 221 ± 19^{stat} ± 19^{syst} MeV

experimental lower bound on T

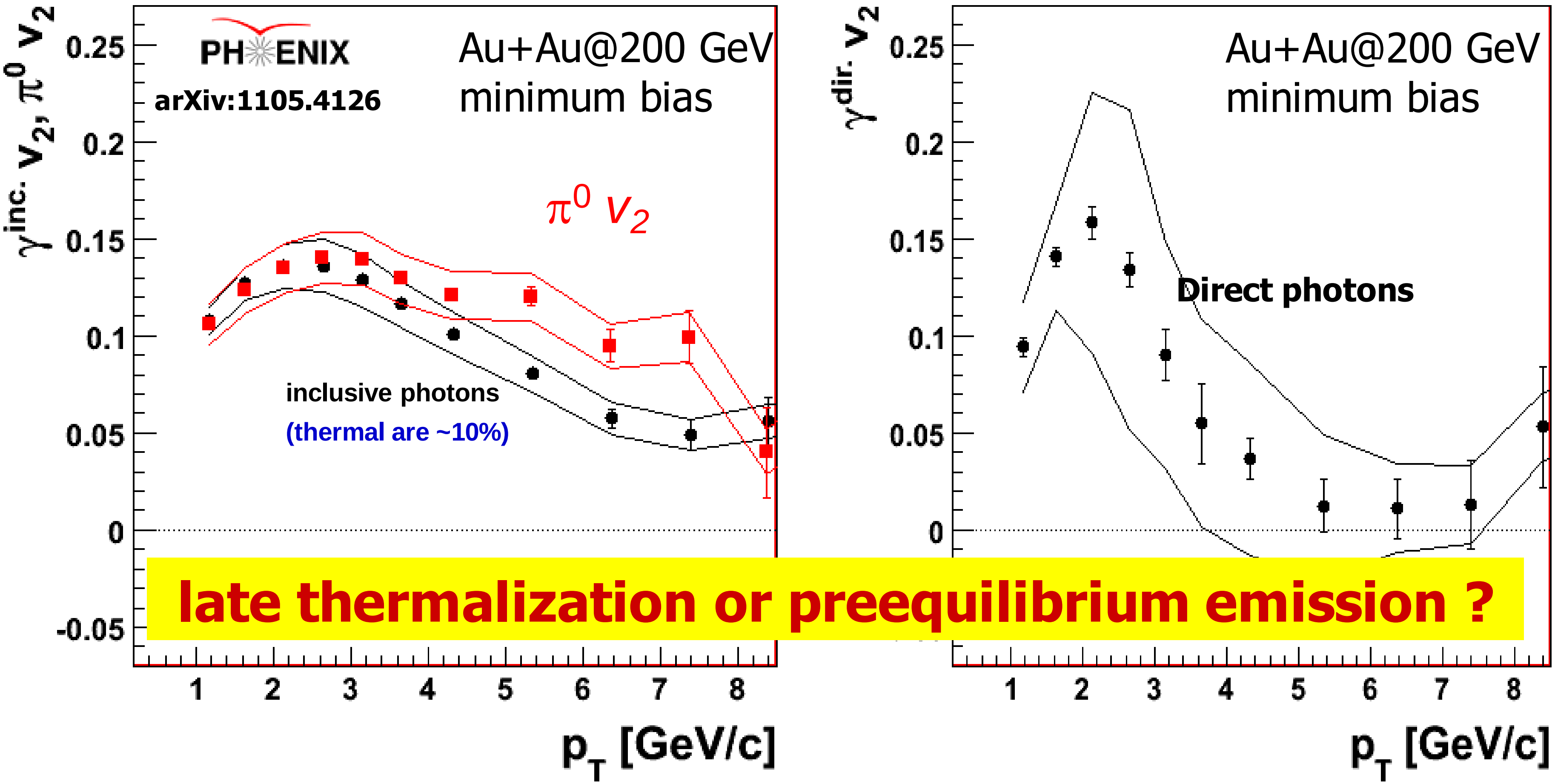


PRL 104 132301(2010), arXiv:0804.416

Thermal photons and thermalization time

Thermal photon dominate below pT~ 5 GeV/c;

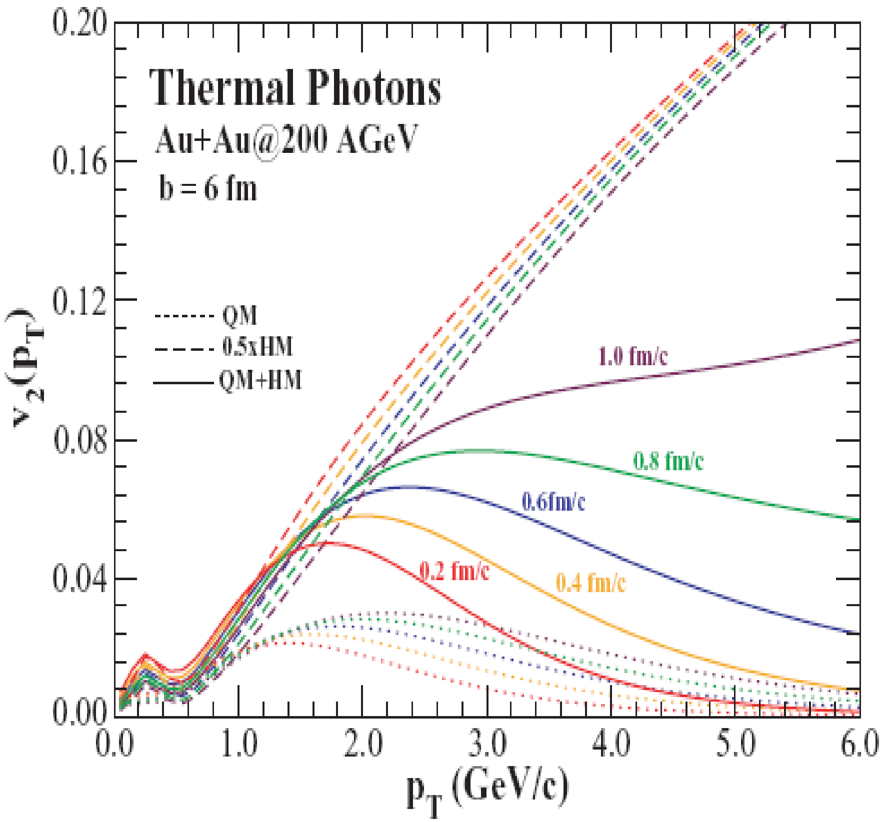
PHENIX: $T_{thermal} = 221 \pm 19^{stat} \pm 19^{syst}$ MeV



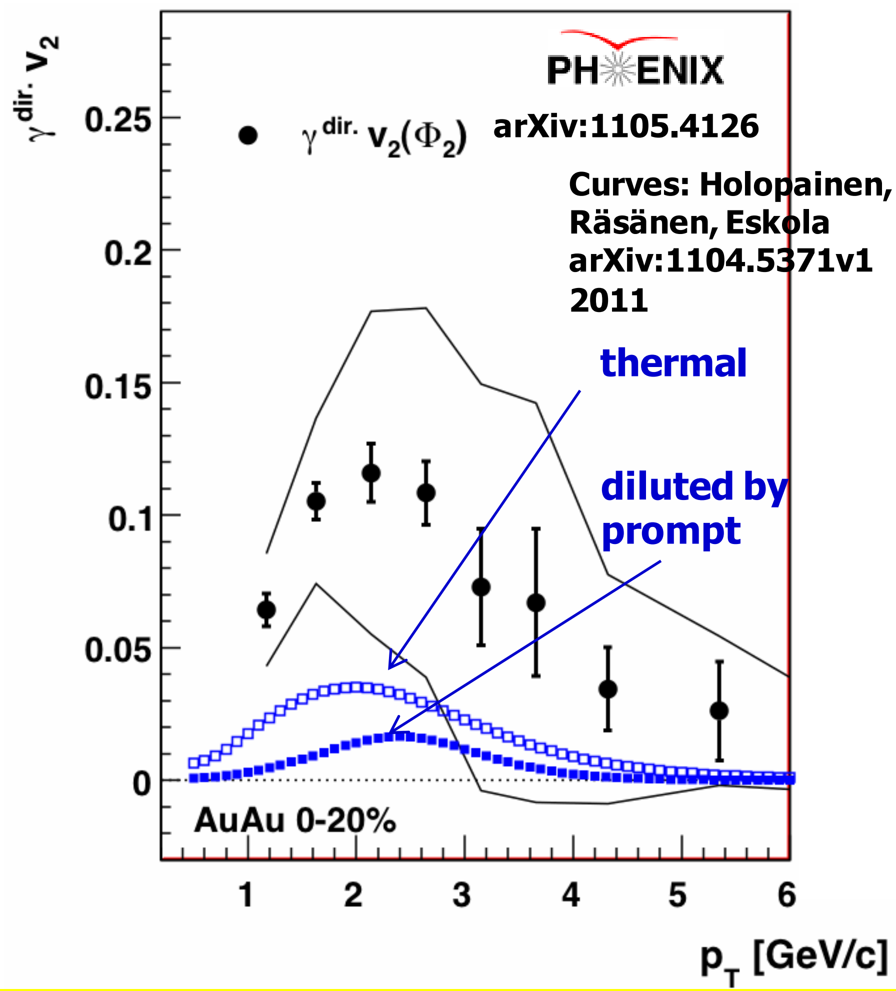
late thermalization or preequilibrium emission ?

Direct photon flow: from intuition to theory

Hydro after τ_0



Chatterjee, Srivastava PRC79, 021901 (2009)



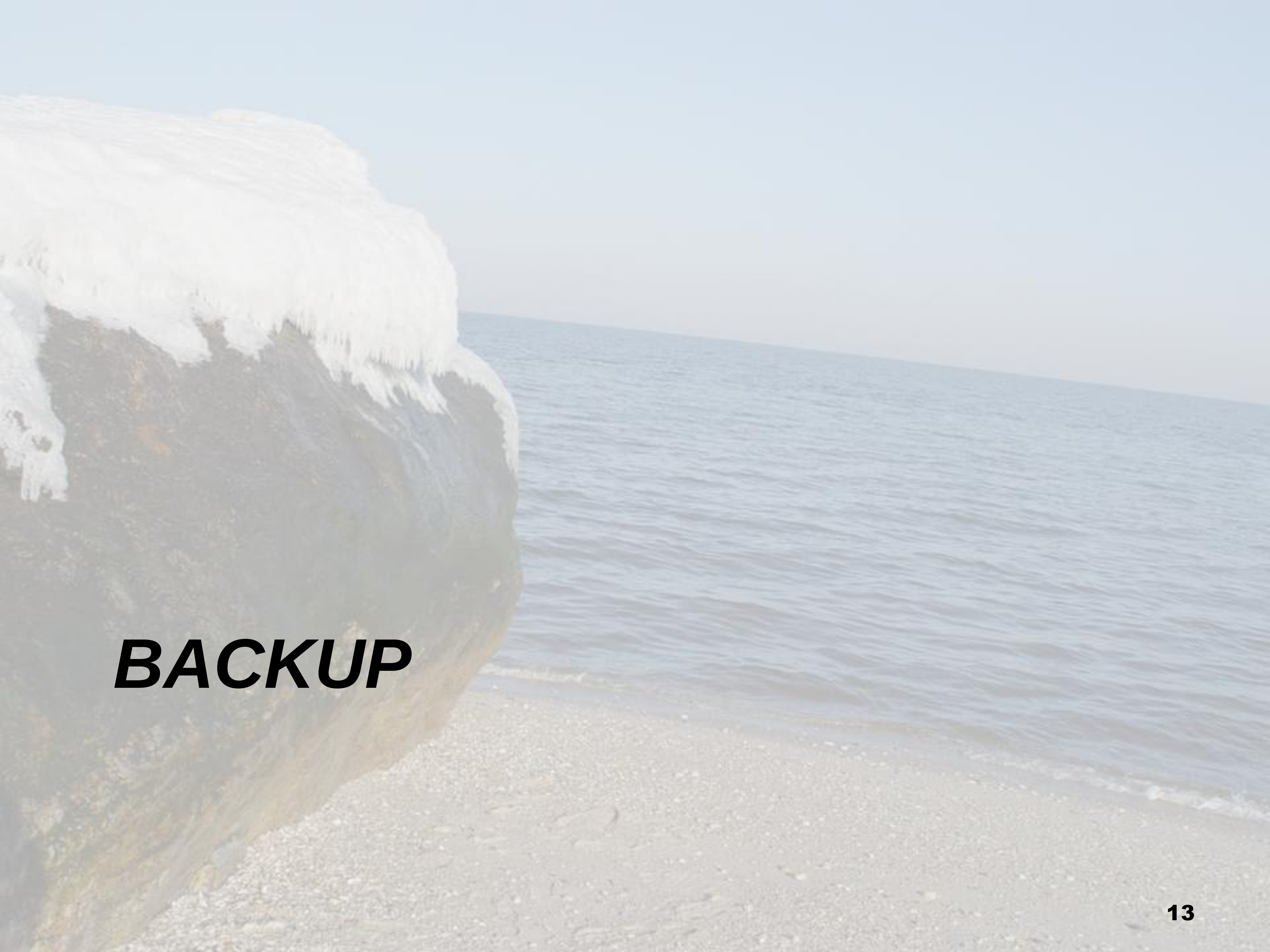
Pattern is right, scale can now be tuned to match experiment

Summary:

- *Direct γ pT spectra are consistent with LO (prompt) & thermal photons being major contributors with little or no visible NLO contribution;*
- *PHENIX prompt photons yield measurements confirm collision scaling;*

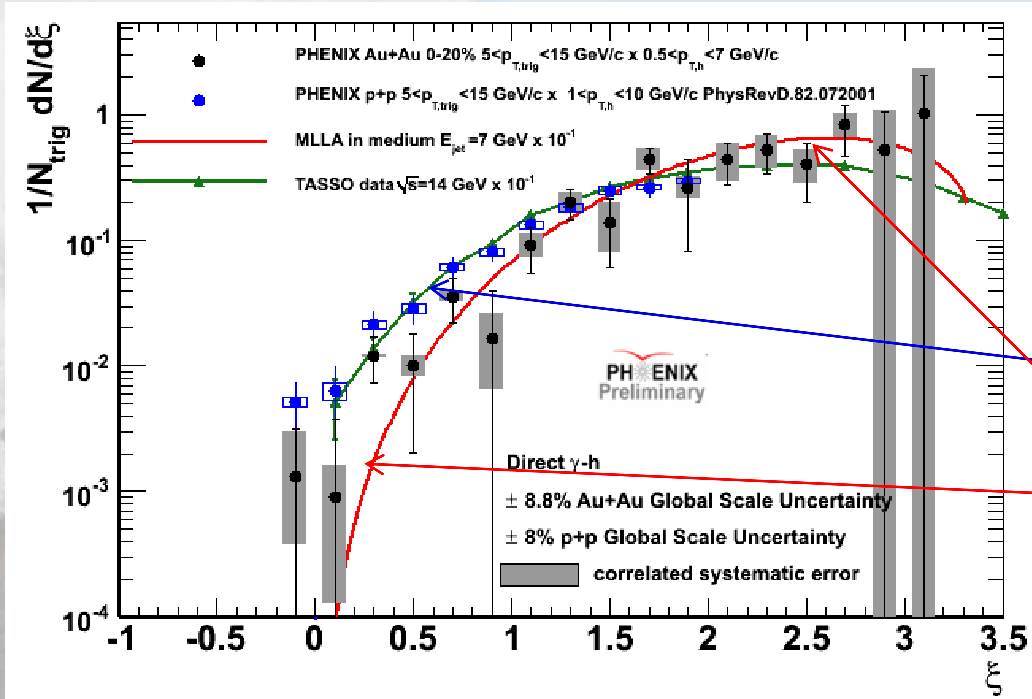
- *Prompt γ's do not flow;*
- *Prompt γ's provide a reasonable estimate for the energy of recoil jet;*
- *Medium softens partonic FF;*

- *Thermal γ's show the flow similar to that of hadrons.*



BACKUP

Partonic FF shape modification



- $x_E = -p_T^h/p_T^\gamma \cos(\Delta\phi) \sim z_T$
- $\xi = -\ln x_E$ - MLLA variable
- Universal scaling in pp
- Enhancement at very low z
- Suppression at large z_T

- ***pQCD photons provide a reasonable estimate for the energy of recoil jet (q or g);***
- ***Measured medium FF is softer compared to vacuum fragmentation;***
- ***Further studies with jets tagged by strangess (gluon / quark jet separation) follow***